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ABSTRACT

In 1968 the New York City Board of Education initiated a large scale test of a computer assisted instruction (CAI) program for drill and practice in elementary arithmetic. The program was a modified version of one developed by Dr. Patrick Suppes of Stanford University. An RCA Spectra 70/45 computer and 192 terminals located in elementary schools throughout the city were used. This report describes the methods used to evaluate the effectiveness of the CAI drill at each grade level, to determine the effect of the CAI drill on the attitudes of teachers, school administrators, parents and students toward CAI, and to examine the effect of the CAI program on teaching procedures in elementary arithmetic. The results of various tests and observations are presented and interpreted. Based on the data collected in the study, some conclusions and recommendations are offered. (JY)

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AN EVALUATION OF THE 1968-1969 NEW YORK CITY COMPUTER ASSISTED INSTRUCTION PROJECT IN ELEMENTARY ARITHMETIC

by

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Introduction

In September 1968 the New York City Board of Education initiated a project for a large-scale test-demonstration of a Computer Assisted Instruction (CAI) program for drill and practice in elementary arithmetic. This program was a modified version of an earlier arithmetic drill and practice program based on work done at Stanford University by Dr. Patrick Suppes and his staff, which had been field tested in various parts of the country. The New York 1968-'69 experiment represented the first demonstration of a CAI arithmetic program of this type in a great metropolitan center. The present report will describe some outcomes of the experiment in the first year of a proposed three-year test period.

The "Hardware"

The New York City CAI Project consists of an RCA Spectra 70/45 computer located at the project headquarters in Manhattan, four line concentrators at convenient locations in The Bronx, Manhattan, and Brooklyn, and 192 terminals located in elementary schools in those boroughs.

The "Software"

The CAI program for drill and practice in arithmetic provides exercises suitable for use in grades two through six. It is designed to complement and support the instruction provided by the teacher, and hence it is intended neither to present concepts nor to provide explanations. It simply offers a carefully organized, varied,

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and minutely graded set of exercises, the exact selection and sequence of which is not rigidly predetermined.

The CAI lessons are so devised that pupils generally can complete them in from two to ten minutes per lesson, whether the purpose is testing, drill only, or drill and review. The pupil receives his instructions and exercises and enters his responses at a terminal, which is to him "the computer" because it displays to him words and number combinations that are responsive to his own behavior.

Plan of Evaluation

The purpose of the evaluation of the 1968-69 New York City CAI Project was to describe the outcomes of the experiment in terms of its effects upon pupils and teachers. More particularly, its purpose was to seek to answer the following questions:

1. What is the effect of the CAI drill and practice program on pupil achievement in arithmetic at each grade level, from grades 2 through grade 6?
2. What is the effect of the CAI drill and practice program on pupil opinions and attitudes toward CAI, toward arithmetic, and toward learning in general?
3. What is the effect of the CAI drill and practice program, and of the adjustments necessary for its use, on teaching procedures in elementary arithmetic?
4. What is the effect of the CAI drill and practice program on the opinions and attitudes of teachers, school administrators, and parents?

In addition, information was sought on a number of subsidiary questions, which will be detailed further at appropriate points in the present report.

The plan of evaluation was not - and, under the circumstances, could not have been - designed as a precise scientific experiment in which the variable under investigation was applied in a predetermined manner and all other contaminating influences rigorously excluded. With respect to the question about pupil achievement in arithmetic, however, it was cast in the form of a quasi-experiment- that is, pupils receiving arithmetic instruction under CAI and non-CAI conditions, selected so as to be as comparable as possible beforehand, were compared on tests taken at the beginning and end of the school year.

The Evaluation Team

The City University of New York, by agreement with the New York City Board of Education, supplied the evaluation team, consisting of directors, consultants, and staff assistants. In addition, six professors in mathematics education, members of the faculties of the senior colleges of the City University, were employed to observe pupils in the CAI and non-CAI schools under study as part of the evaluation. They visited classrooms and CAI centers in the schools and also interviewed teachers, paraprofessionals, and school principals.

Selection of Schools and Classes

Participation in the CAI experiment was accomplished by the staff of the Board of Education prior to the employment of the Evaluation team. The idea was first presented to district superintendents. Three expressed interest in applying the program in the schools under their jurisdiction. Each district superintendent, in his own fashion, then selected the schools that he judged most suitable, generally after consulting with the school principals under his supervision. Later, in order to provide for comparison between CAI and non-CAI learning situations in which all

other conditions would be as nearly alike as possible, the district superintendents were asked to designate control schools on the basis of similarity to the CAI schools in the ethnic and socio-economic composition of their pupil populations and the judged equivalence of their administrative and instructional staffs.

Sixteen CAI schools and four non-CAI schools were designated. Arrangements were then made for the collection of data by achievement testing, observation, and interviews or questionnaires, in each school.

Within schools the selection of classes to participate in the CAI experiment was left entirely to the principals with the stipulation that intact class groups from each grade level from two to six should be included. As a rule, principals selected those teachers whom they judged capable of using the CAI program effectively and who expressed a desire or willingness to participate.

Physical Arrangement of CAI Terminals in Schools

On the average twelve CAI terminals per school were provided, the exact number depending on the particular circumstances in each school. The most usual arrangement for the use of the CAI equipment was to place all the terminals in a single room and bring the pupils there in groups. Under this plan a schedule for the use of the "CAI center" was worked out, and the paraprofessionals were assigned to escort groups of pupils to and from their classrooms as well as to supervise the use of the terminals at the center. In some schools, however, the CAI terminals were located in separate classrooms--two schools had single terminals in each of twelve and thirteen classrooms, respectively, and two others had two terminals in each of six classrooms and a single terminal in a seventh. Under these circumstances individual children worked by turns at the terminal while the teacher and the other children were carrying on other activities.

Special Training Programs for Teachers and Paraprofessionals

Under the general plan of the New York City CAI Project, as developed by th

Board of Education, RCA provided for the initial training of participating teachers. This consisted of a 10-hour course held in the spring of 1968, which was attended by teachers from schools that would be using CAI in 1968-69. Although the teachers' strike in the fall of 1968 resulted in some attrition, nearly 85 per cent of the original teachers were still in the program after the strike. Copies of the RCA Teachers' Guide, which was gone over in detail during initial training, were given each teacher for use during the school year.

To assist the teachers in using CAI effectively, and especially to assist them in coordinating the CAI drill and practice program with the regular arithmetic curriculum, additional training and supervision were provided by the project director and by the curriculum specialists on his staff. At first district-wide workshops were organized, but after December it was decided that workshops should be conducted in each school so that problems peculiar to individual schools could be considered separately.

The paraprofessionals were given six hours of training in the spring and two additional hours in the fall. Each paraprofessional received a manual covering some of the important aspects of the job: care of the CAI center (or of terminals in separate classrooms), maintaining discipline, changing paper and ribbons on the terminals, and a step-by-step procedure for detecting the sources of mechanical problems.

Instruments

Achievement Tests

The Metropolitan Achievement Test (MAT) was chosen, after consultation with the Bureau of Research, because it is used extensively by the New York City Board of Education in evaluating pupil achievement and hence would provide comparability of measurement between the present study and other studies. The levels, specific tests, and forms selected were as follows:

Grade 2	Primary II Battery (Form C). Test 5, Arithmetic Part A: Concepts & Problem Solving. Test 5, Arithmetic Part B: Computation.
Grades 3 and 4	Elementary Arithmetic Test (Form C). Test 1, Arithmetic Computation. Test 2, Arithmetic Problem Solving and Concepts.
Grades 5 and 6	Intermediate Arithmetic Test (Form CM). Test 1, Arithmetic Computation. Test 2, Arithmetic Problem Solving and Concepts. (Form CM can be scored either by hand or by machine.)

The same test forms were used as pre- and post-tests, and for analysis the raw scores were used. Thus no differences of scale affect the before-and after comparisons within a level and loss of precision by conversion of scale is avoided, but summation across levels is impermissible because the raw score scales of the three levels of the test are different. The experiment is sufficiently large, to permit all comparisons to be held within school grades. The reader should keep in mind, in looking at the results that each level of the test is more difficult than the preceding one.

Observation Record

Observation was considered essential to the evaluation despite its inherent difficulties, which were intensified, as it turned out, by events affecting the whole city and its school system. An observation record form had been developed in advance, but the process of modifying it to make it acceptable to all persons concerned was interrupted by the teachers' strike. After substantial delay and some necessary compromise, a revised version was developed and approved for use in the schools participating in the study.

Interview Schedules (Questionnaires)

To provide adequately for the reporting of the opinions and attitudes of the members of each major group concerned with the New York City CAI project, the achievement test data and observation records needed to be supplemented by some

kind of direct expression from participants. Therefore pupils, teachers, para-professionals, school administrators and parents were asked to respond to questions designed to elicit in a systematic way their perceptions of the CAI program and its effects.

TEST RESULTS

Introduction

Before discussing any of the test results, it must be emphasized that the constraints involved in the collection of the test data do not permit our saying with any degree of surety that any of the gains found were attributable to CAI alone. There were many other variables which might have influenced the results.

When all of the students' scores were examined, the mean raw score gains between the January pre-test and June post-test were higher, in all grades, for the CAI groups. This was true regardless of whether the data were grouped by total schools or by sex.

The differences in gain scores were significant for grades 2, 3 and 5 for all students.

The MAT Results of Schools With a Predominantly Black or Puerto Rican Population

Among the 20 schools which took part in the evaluation, there were 5 CAI and 2 non-CAI schools with a 90% or more Black or Puerto Rican population. Generally, these schools may be characterized as being in the poorest sections of the boroughs in which they are located. There were significant differences in gains in grades 2 and 3 in these schools. When grouped by sex the CAI girls showed a significantly higher gain in grades 2 and 3. None of the differences were significant for the boys.

Additional Analyses

It seemed appropriate to determine what the gains would be when the students in the non-CAI group were matched with the CAI group according to pre-test computation scores. This was done and a total of 333 matched pairs were identified. Also a covariance analysis was undertaken.

All scores on the computation pre-test were listed in ascending order by sex and grade in the data file. For each non-CAI computation pre-test raw score a match was found by computer in the CAI group. If an exact match were not found, the program was set up to select a score within 1 point of the score to be matched. Where more than one CAI student earned a score which could be matched with a non-CAI student's score, the computer selected one at random.

As previously, the CAI students scored higher gains than the non-CAI students. This was also true when the data were listed by sex. The differences were significant in all groupings for grades 2, 3 and 5.[1]

Data from Student Records Maintained by Computer

CAI offers the educator the unique opportunity to study the process students go through in solving an arithmetic problem. In the present study an attempt was made to determine 1) how long students take to solve a problem (latency), 2) how many errors they make and 3) how often students were "timed out" by the computer, i.e. how often they failed to respond within the time limit (ten seconds) built into the CAI program. Unfortunately the program was not designed to elicit this important information easily and economically.

For purposes of comparison, the group was divided into two parts. The question which this division was intended to answer was whether the program was differentiated enough for students who are highest and lowest in arithmetic ability. The selection of students, therefore, was

[1]The covariance analysis confirmed the significant differences in grades 2, 3 and 5 for all the students in all the schools and grades 2 and 3 for students in schools with a predominantly Black or Puerto Rican population.

on the basis of the pre-test total scores, i.e. scores from the computation and concepts subtests combined. The results showed that at each grade level and for each problem answered, the low group required more time than the high group, 2) the mean error rate of the low group exceeded that of the high group, and 3) the mean number of time outs was also higher for the low group. These data are based on a very small sample of 66 students.

Summary and Conclusions on Test Data

A consistent pattern of gains was found for most CAI groups. That is, the CAI students earned higher gains in most grades, with significant differences found in the following:

1. Grades 2, 3, and 5 for all students in all schools.
2. Grades 2 and 3 for girls in all schools.
3. Grades 2, 3, and 5 for boys in all schools.
4. Grades 2 and 3 for all students in schools with predominantly Black or Puerto Rican population.
5. Grades 2 and 3 for girls in schools with a predominantly Black or Puerto Rican population.

Classroom Activities - Observers Reports

1. The observers found no appreciable differences in instructional procedures in classes using CAI as compared to those not using CAI.
2. Over a period of several months no significant changes in teaching style, instructional procedures, or pupil behavior were noted in classes using CAI.
3. While the observers were present, teachers tended to teach review lessons or lessons unrelated to the concepts for which the CAI program would provide drill and practice.

4. Mathematics lessons ranged in length from 20 to 60 minutes; most were approximately 30-35 minutes.

5. With few notable exceptions, there was little evidence of grouping for mathematics instruction, or of other ways of providing for individual differences.

6. The observers found no appreciable reduction in the amount of class time spent in drill and practice in CAI classes. In fact, many of the lessons observed, both CAI and non-CAI, could be classified as "practice" lessons. Drill and practice made up a significant part of each lesson; there was little reason to suspect that a computer was being used for that purpose exclusively. The percent of the lesson devoted to drill and practice ranged from 20% to 100% in all the classes, most teachers devoting about two-thirds of the lesson to drill and practice.

7. A few of the teachers observed, devoted complete lessons preparing children to practice a particular topic on the computer. Furthermore, some teachers used a complete lesson for reteaching a topic because students had encountered unfamiliar symbols or abbreviations at the terminal.

8. The instructional materials used in most classrooms included: textbooks, workbooks, rexographed materials, overhead transparencies, teacher demonstration models. In some classes, instructional materials were provided for each child, e.g., fraction kits, clocks, cut-outs for sets, Cuisenaire rods, etc.

9. Several teachers substituted computer practice for homework assignments.

The Teacher and His Reaction to CAI

1. Most teachers observed had an adequate understanding of the concepts

being taught. The exceptions to this ranged from several teachers who were exceptionally competent in mathematics to those (not few in number, whose background in mathematical concepts was uncertain or exceedingly sketchy, particularly in "modern math."

2. Teachers used either textbooks or curriculum bulletins to plan their lessons. Few teachers indicated that they used the CAI teachers' guide in preparing lessons to any great degree.
3. Although teachers had reservations about the values of the CAI project, they felt that pupil enthusiasm and participation justified it and recommended its continuation. Teachers comments on CAI varied. Some positive comments concerning CAI were:
   a. it motivates good behavior;
   b. provides supplemental individualized drill;
   c. relieves teachers of some guilt feelings by providing children with needed drill that the teacher has no time to give;
   d. develops pupils' speed in computation;
   e. has potential for keeping track of where each pupil is.

Some negative comments were:

   a. the lack of correlation of CAI and regular curriculum was a major stumbling block; there was a growing gap between the classroom and CAI center activities;
   b. there was a need for greater control by the teacher of the program as a teaching supplement;
   c. some difficulties, such as discipline problems and classroom disruptions, arose as a result of children moving back and forth to terminals or CAI center;

d. there was too little opportunity for teachers to discuss needs and problems with paraprofessionals, CAI coordinator, and mathematics coordinator.

4. Some teachers believed that their own class tests and practice sheets were superior to and more relevant than what the children practiced at the terminals.

Students and Their Reaction to CAI

1. Almost all teachers agreed that children enjoyed working on the computer, were enthusiastic about it, and were highly motivated to do well. This was particularly true of children of average ability.

2. In spite of some frustrations and difficulties encountered by some children at the outset, most children have remained extremely enthusiastic about the "machine."

3. Children of average and above average ability tended to enjoy the privacy of working at the terminal and even talked to the "machine."

4. Teachers indicated that CAI encouraged pupils to commit their "number facts" to memory so that they would be able to respond in the time allowed by the computer.

5. Some slower children tended to do a great deal of guessing and appeared to be playing games rather than practicing the skills needed to do their classwork.

Paraprofessionals

1. The paraprofessionals were an extremely enthusiastic, interested and dedicated group. They took their role in this experiment most seriously and were anxious for the program to succeed and to continue.

2. Paraprofessionals felt that teachers needed to be more directly and actively involved in the CAI activities and achievements of pupils. Many indicated a need for closer coordination of classwork and CAI work. Pupils who were either far ahead or far behind a class presented problems with which they were unable to cope.
3. The paraprofessionals considered the CAI center the most popular room in the school.

Summary

From the observations it appeared that CAI had little effect on teaching style or instructional procedures, on grouping and individualization of mathematics instruction in the classroom, on the amount of time devoted to drill and practice, and on increasing the emphasis on concept development in the classroom presentations. There was little coordination between CAI and the regular mathematics instruction -- with CAI assuming a subordinate role. Thus, there were discrete classroom activities and discrete CAI activities either at a center or in a classroom. The prevailing attitude seemed to be that as long as the pupils enjoyed it, that was sufficient.

INTERVIEWS AND QUESTIONNAIRES

The reactions and attitudes of those connected with the CAI program (teachers, students, school administrators, and parents) were obtained either by interview or by questionnaire.

Administrators' Attitudes & Perceptions

Principals were asked a number of questions regarding pupils' work at the terminals. They overwhelmingly felt that (1) students enjoyed using the CAI terminals, (2) students enjoyed working problems at the terminals, and (3) students benefitted from working at the terminals.

Teachers Estimate of Time

Teachers were asked to estimate their preparation time and time spent in drill and practice. The responses indicated that CAI teachers said they spent a greater amount of time on preparation than did non-CAI teachers. As many as 8% of CAI teachers spent as much as 75% of their time in drill and practice. Teachers in both groups agreed that their drill & practice time would leave them enough time for teaching concepts. In CAI schools, 128 teachers agreed and 12 felt that the time was inadequate; and in non-CAI schools, 12 agreed, and one felt the time inadequate.

Teachers Attitudes & Perceptions

Teachers were asked if they were satisfied with their students

performance, in view of the time they devote to mathematics. In CAI schools 65% of the teachers indicated that they were satisfied, and 27% indicated that they were not satisfied. In non-CAI schools, 50% indicated that they were satisfied, and 43% indicated that they were not.

Parent Attidudes & Perceptions

According to parents, fewer children in CAI schools show a strong dislike for arithmetic than do children in non-CAI schools. There is greater communication between the children and their parents in CAI schools than in non-CAI schools since only 4.7% of the CAI parents indicated that they were unaware of their children's attitude toward arithmetic whereas 16% of the non-CAI parents claimed they were unaware.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

On the basis of the study of the New York City CAI project for the 1968-1969 year of operation, the evaluation team has reached the following major conclusions:

1. Very systematically, in nearly all groups, the CAI students made greater gains in arithmetic achievement as measured by the Metropolitan Achievement Tests (MAT) than the non-CAI students whom they were compared. In all cases in which the differences were statistically significant, they favored the CAI group.

2. Answering differences between CAI and non-CAI groups, each grade was considered separately, and the following principal comparisons showed significant differences in favor of the CAI groups:
   a. Matched pairs of students drawn from entire student population: grades 2, 3 and 5.
   b. All students in all schools: grades 2, 3, and 5.
   c. All students in schools with a predominantly Black or Puerto Rican population (90% or more): grades 2 and 3.
3. Though the gains earned by many CAI groups were rather impressive, many variables not controlled in the present study could very well have contributed to the differences in the earned gains. Among these uncontrolled variables are the following:
   a. selection of teachers.
   b. selection of schools.
   c. number of hours of arithmetic instruction.
   d. instruction for CAI children by personnel other than their teachers (viz. paraprofessionals) and
   e. stress given to arithmetic by faculty and students in CAI schools.
4. Observers were not able to detect differences in instructional procedures as between CAI and non-CAI classes.
5. Observers found no appreciable reduction in the amount of time spent in drill and practice in CAI classes. Drill and practice usually made up a significant part of each lesson in CAI as well as non-CAI classes.

6. Little evidence that teachers were using the CAI Daily Status Reports and Concept Block Progress Reports for purposes of individualizing mathematics instruction, was encountered by the observers. The observers found that grouping for arithmetic instruction was infrequent in both the CAI and non-CAI groups.
7. The observers concluded that a number of teachers needed further training in the subject matter of mathematics as well as in the appropriate use of CAI.
8. A large percentage of all categories of respondents to interviews or questionnaires had a favorable attitude toward CAI and felt that work at the terminals helped the children learn arithmetic better.
9. There was evidence, according to interviews and questionnaires, that CAI students tended to have a higher rate of communication with their parents about school work and arithmetic than did non-CAI students.
10. CAI teachers reported having to spend a somewhat greater amount of time in lesson preparation.
11. On the basis of very small samples, there was evidence found that the CAI arithmetic program (software) may not differentiate well enough for the high or low achievers. The software offered problems at five levels of difficulty based on an achievement pretest taken at the terminals. If this has provided sufficiently for individual differences one would assume that there would be

very little, if any, difference between error rates and time-outs for children at different ability levels. The findings showed that the low achievers require more time to do each problem and make more errors than the high achievers.

Recommendations

1. It seems quite important that future evaluations of student achievement in CAI take into account as many as possible the variables not controlled in the present study (see item 3, above). One area in particular, should be monitored, if not controlled, and that is the amount of instruction the children in both CAI and non-CAI schools receive in drill and practice.
2. A more specific evaluation should be made of the software and its relevance for children at different levels of ability. It may well be, for example, that low achievers need more time at the terminals while high achievers require less scheduled time. It may even be the case that the present software is inappropriate for one or both extreme groups. This recommendation was supported by observers in their reports as well as by the data from student records.
3. There should be more CAI mathematics coordinators who are familiar with the software available to the CAI teachers for assistance regarding content as well as method.